



W&M ScholarWorks

---

## Reports

---

10-1-1991

# Preliminary Assessment of the Economic Impacts of Various Catch and Effort Restrictions on the United States Sea Scallop, *Placopecten magellanicus*, Fishery

James E. Kirkley  
*Virginia Institute of Marine Science*

William D. DuPaul  
*Virginia Institute of Marine Science*

Follow this and additional works at: <https://scholarworks.wm.edu/reports>

 Part of the [Aquaculture and Fisheries Commons](#)

---

## Recommended Citation

Kirkley, J. E., & DuPaul, W. D. (1991) Preliminary Assessment of the Economic Impacts of Various Catch and Effort Restrictions on the United States Sea Scallop, *Placopecten magellanicus*, Fishery. Marine Resource Report No. 91-5; VSG-91-04. Virginia Institute of Marine Science, College of William and Mary. <http://dx.doi.org/doi:10.21220/m2-qxyt-1a03>

This Report is brought to you for free and open access by W&M ScholarWorks. It has been accepted for inclusion in Reports by an authorized administrator of W&M ScholarWorks. For more information, please contact [scholarworks@wm.edu](mailto:scholarworks@wm.edu).

VIRGINIA SEA GRANT  
COLLEGE PROGRAM



***Preliminary Assessment of the  
Economic Impacts of Various  
Catch and Effort Restrictions on  
the United States Sea Scallop,  
Placopecten magellanicus, Fishery***

*James E. Kirkley, William D. DuPaul*

VSG-91-04



This work is a result of research sponsored in part by the National Sea Grant College Program of the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, under Grant No. NA86AA-D-SG042 to the Virginia Marine Science Consortium and the Virginia Sea Grant College Program. The U.S. Government is authorized to produce and distribute reprints for governmental purposes notwithstanding any copyright notation that may appear hereon.

Preliminary Assessment of the Economic Impacts of Various  
Catch and Effort Restrictions on the United States  
Sea Scallop, Placopecten magellanicus, Fishery<sup>a</sup>

James E. Kirkley<sup>b</sup>

William D. DuPaul<sup>b</sup>

Sea Scallop Plan Development Team<sup>c</sup>

Virginia Marine Resource Report No. 91-5

---

<sup>a</sup>Research for the economic analysis was, in part, funded by the Virginia Sea Grant Program, Award Number NA 90aa-D-56045. This report could not have been prepared without the assistance and data provided by numerous members of the sea scallop fishing industry.

<sup>b</sup>College of William and Mary, School of Marine Science, Virginia Institute of Marine Science, Gloucester Point, VA.

<sup>c</sup>The Plan Development Team provided a preliminary review of the economic assessment contained in this report.

## Introduction

This report provides a brief preliminary assessment of the economic impacts on full-time dredge vessels of various proposed alternative regulations:<sup>1</sup> (1) layover days (4 days, 1:1, and 1:2), (2) 10,000 pound trips limits, (3) 9 man crew, (4) 15-foot dredges, and (5) an annual days at sea allocation. The report also provides a preliminary assessment of the effects on harvest levels and revenues of imposing a 3.5-inch ring size restriction. Impacts are measured in terms of average annual returns to owner, captain, and crew, number of trips per year, and fleet landings.

The reader is cautioned to remember that the impacts presented in this report are in terms of yearly or annual averages. Vessels, captains, and crew rarely operate at the average level. Estimated impacts, thus, may be extreme for some vessels and minimal for other vessels. The problem of using vessel averages is further illustrated in an assessment of impacts on ten tonnage class 3 vessels and one tonnage class 4 vessel.

Empirical analyses illustrate several problems with the proposed regulations that should be of concern to the

---

<sup>1</sup>For additional information, see Kirkley, J.E. and W. D. Dupaul, (1990), "A Review of the Fishery Management Plan for Sea Scallops, Placopecten magellanicus. Marine Resource Report No. 90-3, College of William and Mary, Virginia Institute of Marine Science, Gloucester Point, VA 23062.

Scallop Committee, the New England Fishery Management Council, and the industry. Foremost among the problems is that most of the proposed regulations that restrict harvest levels to 30 or fewer million pounds and allow a fleet of 200 or more vessels will severely affect economic performance and returns relative to 1987-1990 levels. Many of the proposed regulatory constraints will likely force several vessels out of the fishery; they will be unable to cover quasi-fixed costs and rate of return on investment.

Imposition of trip quotas will increase the potential for extreme economic inefficiency or waste. They will more severely affect those vessels taking longer trips and regularly harvesting in excess of 10,000 pounds per trip. These vessels will be forced to reorganize their fishing activities and take shorter and more frequent trips to mitigate the adverse effects of a quota. The Scallop Committee and Council should keep in mind that such energy inefficient regulations would not be consistent with energy conservation policies of the Department of Energy and the Office of Management and Budget. Trip quotas under certain resource conditions, however, may minimize excessive harvesting of small scallops from a strong entering year class. Without meat count or ring size restrictions, trip quotas offer one possible way to reduce the harvesting of concentrations of small scallops.

Levels of restrictions necessary to achieve apparent desired reductions in effort or nominal catch appear

to create extreme economic hardship for the industry (e.g., a 10,000 pound trip limit and a 1:1 layover will likely force many vessels to tie up between October and January, reduce fishing activities particularly during those months when 10000 pounds per trip may be difficult to obtain, or exit from the fishery). Extreme hardship is quite likely if average ex-vessel price falls below \$3.50 per pound and fuel prices are \$.75 or higher per gallon; given the historical nature of fuel prices and world situation for crude, it is very likely that fuel prices will increase beyond \$.75 per gallon.

Many of the proposed regulations, if actually limiting, will be partly circumvented by industry seasonally reorganizing fishing activities. The analyses suggests that vessels will curtail fishing activities between October and January and take advantage of periods with high expected revenues during the spring. Curtailing fishing activities pose two problems for industry. First, if landings are regularly reduced between October and January, foreign suppliers will have an opportunity to increase market penetration and market share; this will be particularly true for the Chinese which already export large quantities of bay scallops to the United States in December and January. Second, vessel owners and captains may experience problems attracting crew during desired fishing seasons if they will only be able to work 9-10 months per year.

## Methodology

The economic impacts were estimated using several econometric (statistical) and simulation (mathematical) models. Using panel data (trip level data for approximately 35 vessels operating between 1987 and 1990), catch-effort and expenditure and cost models were estimated. These models were used to estimate catch and performance at the trip level and over a year. The catch models specified catch as a function of days at sea, crew size, and stock abundance (a geometric mean index based on information obtained on a weekly basis):

$$C_{it} = f(DAYS_{it}, CREW_{it}, SA_{it})$$

where C stands for catch in pounds of meats, DAYS equals days at sea per trip, CREW is number of crew per trip, SA equals stock abundance, and i and t indicate the ith vessel and tth trip.

Estimation was accomplished by generalized least squares to correct for two statistical problems (heteroscedasticity and autocorrelation) that cause estimates to be inadequate. Numerous statistical methods were used to determine functional form and data separations (F-test, Wald test, Cusum and Cusum-squared, Box-Cox, and Cox-tests). The simulation models were mathematical models that define the various lay systems and allow costs to be estimated for various levels of fishing activity.



The economic impacts presented in this report were based on a 50-50 split of the net stock (gross stock less fuel expenditures less miscellaneous expenses). The simulation model and the statistical catch-effort models were used to estimate total fleet landings subject to the assumption that all vessels have the same average performance and face the same long-run average resource condition.

Examination of possible differences among vessels was accomplished by examining the 1990 performance of 11 individual vessels. Thus, 11 catch effort and simulation models were developed; one for each vessel. Equality of fishing operations were tested by the standard F and Wald tests; these are two statistical tests that allow differences to be statistically examined.

## Results

### Average impacts:

Using the statistical equations and the simulation model, a trip quota of 10,000 pounds, 3 types of layover day restrictions, and a 9 man crew were examined for tonnage class 3 and 4 vessels (Tables 1-2).<sup>2</sup> This particular simulation assumed long-term average resource conditions (a

---

<sup>2</sup>Additional assumptions about costs may be obtained from Kirkley and DuPaul.

TABLE 1. ESTIMATED LANDINGS, ECONOMIC RETURNS, AND FLEET LANDINGS FOR 10000 TRIPS LIMITS, 1:1, 1:2, AND 4 DAY LAYOVER RESTRICTIONS AND 9 MAN CREW: MEDIUM SIZE VESSELS<sup>a</sup>

DAYS	LBS. VESS.	ECONOMIC RETURN			TRIPS	FLEET LANDINGS NUMBER OF VESSELS				
		OWN	CAP	CREW		150	175	200	225	
<hr/>										
--\$THOUSANDS--					---MILLION POUNDS---					
4 DAY LAYOVER										
10	6760	243 285	43 52	18 <sup>b</sup> 22	26.1	26.4	30.8	35.2	39.7	
12	8234	262 307	48 57	20 25	22.8	28.3	33.1	37.8	42.5	
15	10000 [14.33] <sup>c</sup>	277 324 <sup>d</sup>	51 62	22 27	19.9	29.9	34.8	39.8	44.8	
1:1 LAYOVER										
10	6760	170 199	30 36	12 15	18.3	18.5	21.6	24.7	27.8	
12	8234	175 205	32 38	13 17	15.2	18.9	22.0	25.2	28.3	
15	10000 [14.33]	177 207	33 39	14 18	12.7	19.1	22.3	25.5	28.7	
1:2 LAYOVER										
10	6760	227 265	40 49	16 21	24.3	24.7	28.8	32.9	37.0	
12	8234	233 273	42 51	18 22	20.3	25.2	29.4	33.6	37.8	
15	10000 [14.33]	236 277	44 53	19 23	17.0	25.5	29.7	34.0	38.2	

<sup>a</sup>Numbers in tables depict short-run impacts.

<sup>b</sup>Estimated performance for \$3.50 and \$4.00 ex-vessel price.

<sup>c</sup>Vessels harvest 10,000 pound quota in 14.33 days.

<sup>d</sup>Quasi-fixed cost and 10% rate of return equals = \$215,000

TABLE 2. ESTIMATED LANDINGS, ECONOMIC RETURNS, AND FLEET LANDINGS FOR 10000 TRIPS LIMITS, 1:1, 1:2, AND 4 DAY LAYOVER RESTRICTIONS AND 9 MAN CREW: LARGE SIZE VESSELS<sup>a</sup>

DAYS	LBS. VESS.	ECONOMIC RETURN			TRIPS	FLEET LANDINGS NUMBER OF VESSELS				
		OWN	CAP	CREW		150	175	200	225	
<hr/>										
--\$THOUSANDS--					---MILLION POUNDS---					
4 DAY LAYOVER										
10	9259	335 392	61 74	26 <sup>b</sup> 32	26.1	36.2	42.2	48.3	54.3	
11	10000 [10.12] <sup>c</sup>	363 425 <sup>d</sup>	68 81	29 36	25.8	38.9	45.2	51.7	58.1	
1:1 LAYOVER										
10	9259	234 275	43 52	18 23	18.3	25.3	29.6	33.8	38.0	
11	10000 [10.12]	253 296	47 56	20 25	18.0	27.0	31.5	36.0	40.6	
1:2 LAYOVER										
10	9259	313 366	57 69	24 30	24.3	33.8	39.4	45.1	50.7	
11	10000 [10.12]	338 395	63 75	27 33	24.0	36.0	42.1	48.1	54.1	

<sup>a</sup>Numbers in tables depict short-run impacts.

<sup>b</sup>Estimated performance for \$3.50 and \$4.00 ex-vessel price.

<sup>c</sup>Vessels harvest 10,000 pound quota in 10.12 days.

<sup>d</sup>Quasi-fixed cost and 10% rate of return equals = \$330,000

possible objective of the New England Fishery Management Council) as determined by members of the Plan development Team. Based on ex-vessel prices of \$3.50 and \$4.00 per pound and a fuel price of \$.75 per gallon, the 4 day layover and 1:2 layover (1 day at dock for every 2 days at sea) allow tonnage class 3 and 4 vessels to cover fixed costs and provide adequate compensation to owner, captain, and crew provided resource conditions do not fall below the long-run average.

If tonnage class 3 vessels attempt to harvest the quota, they will required approximately 15 days per trip (14.33 days) on average over a year. In actuality, the number of days to realize the quota would seasonally vary; it may take 8-10 days for some trips and vessels and 15-20 days for other trips and/or vessels. At the 4 day or 1:2 layover, however, fleet landings for 150 vessels or more are quite high. Actual fleet landings would be higher than those of Table 1 because estimated landings in Table 1 assume the whole fleet is tonnage class 3. Estimates of fleet landings in Table 1 are, thus, conservative estimates.

If the tonnage class 4 vessels attempt to harvest the 10,000 quota every trip, they will require approximately 10.12 days per trip assuming average resource conditions (Table 2). These vessels would have little difficulty covering expenses and providing adequate compensation for owner, captain, and crew at the 4 day and 1:2 layover. If ex-vessel price fell below \$3.50 per pound, however, the

tonnage class 4 vessels could experience financial problems even under the 1:2 layover. At the 1:1 layover, the tonnage class 4 vessels would likely experience considerable financial problems. Estimated fleet landings in Table 2 are artificially high due to the assumption that the entire fleet behaves as tonnage class 4 vessels.

It is not possible to adequately estimate total fleet landings until data on vessel size distribution are made available and assumptions about number of vessels allowed to remain in the fleet are made. If we assume that under each fleet level category (150 vessels, etc.) that 1990 size distribution will be allowed and apply that to estimated trip landings under the quota and layover day system, we obtain estimated fleet landings (Table 3).

Information contained in tables 1-3 illustrate that if the New England Fishery Management Council desires to reduce total landings below 30 million pounds a year using a layover and trip limit, only the 1:1 layover and a substantial reduction in the number of vessels allowed in the fleet will achieve this objective. The 1:1 layover, however, will likely cause considerable financial difficulty for the full-time fleet.

An annual days at sea allocation substantially mitigates the economic inefficiency of trip limits by allowing vessels to take advantage of economies of time, scale and size (Tables 4-5). To a certain extent, longer trips permit vessel operations to be more profitable;

TABLE 3. ESTIMATED FLEET LANDINGS UNDER 10,000 POUND TRIP  
LIMIT, 3 LAYOVER DAY SCHEMES, 9 MAN CREW, AND 1990  
DISTRIBUTION ON TONNAGE CLASS 3 AND TONNAGE CLASS 4 VESSELS

Layover day:	Fleet Landings Number of Vessels							
	150		175		200		225	
	TC3	TC4	TC3	TC4	TC3	TC4	TC3	TC4
	66	84	77	98	88	112	98	127
-----millions of pounds-----								
4 day layover	34.8		40.6		46.4		52.3	
1:1 layover	23.5		27.4		31.3		35.3	
1:2 layover	31.4		36.6		41.8		47.1	

TABLE 4. ESTIMATED LANDINGS, ECONOMIC RETURNS, AND FLEET LANDINGS FOR RESTRICTIONS ON ANNUAL DAYS AT SEA, MEDIUM SIZE VESSELS AND 9 MAN CREW<sup>a</sup>

DAYS	LBS. VESS.	ECONOMIC RETURN			TRIPS	FLEET LANDINGS NUMBER OF VESSELS				
		OWN	CAP	CREW		150	175	200	225	
<hr/>										
\$THOUSANDS					MILLION POUNDS					
150 ANNUAL DAYS										
10	6760	140 164	25 30	10 <sup>b</sup> 13	15.0	15.2	17.7	20.3	22.8	
15 <sup>c</sup>	10466	146 171	27 32	12 15	10.0	15.7	18.3	20.9	23.6	
20	13719	143 <sup>d</sup> 167	27 32	12 15	7.5	15.4	18.0	20.6	23.2	
200 ANNUAL DAYS										
10	6760	186 219	33 40	13 17	20.0	20.2	23.7	27.0	30.3	
15	10466	194 227	36 43	16 19	13.3	20.9	24.4	27.9	31.4	
20	13719	191 223	36 43	16 20	10.0	20.6	24.0	27.4	30.9	
225 ANNUAL DAYS										
10	6760	210 246	37 45	15 19	22.5	22.8	26.6	30.4	34.2	
15	10466	219 256	41 49	18 22	15.0	23.6	27.5	31.4	35.3	
20	13719	214 251	41 49	18 22	11.3	23.2	27.0	30.9	34.7	

<sup>a</sup>Numbers in tables depict short-run impacts.

<sup>b</sup>Estimated performance for \$3.50 and \$4.00 ex-vessel price.

<sup>c</sup>Maximum profit occurs for approximately 15-day trips.

<sup>d</sup>Quasi-fixed cost and 10% rate of return equals = \$215,000

TABLE 5. ESTIMATED LANDINGS, ECONOMIC RETURNS, AND FLEET LANDINGS FOR RESTRICTIONS ON ANNUAL DAYS AT SEA, LARGE SIZE VESSELS AND 9 MAN CREW<sup>a</sup>

DAYS	LBS. VESS.	ECONOMIC RETURN			TRIPS	FLEET LANDINGS NUMBER OF VESSELS				
		OWN	CAP	CREW		150	175	200	225	
<hr/>										
--\$THOUSANDS--					---MILLION POUNDS---					
150 ANNUAL DAYS										
10	9259	193 225	35 42	15 <sup>b</sup> 19	15.0	20.8	24.3	27.8	31.2	
15 <sup>c</sup>	17141	247 288	48 57	22 27	10.0	25.7	30.0	34.3	38.6	
20	23423	255 <sup>d</sup> 297	51 60	24 28	7.5	26.4	30.7	35.1	39.5	
200 ANNUAL DAYS										
10	9259	257 301	47 57	20 25	20.0	27.8	32.4	37.0	41.7	
15	17141	330 384	65 76	30 36	13.3	34.3	40.0	45.7	51.4	
20	23423	340 395	68 80	32 38	10.0	35.1	41.0	46.8	52.7	
225 ANNUAL DAYS										
10	9259	289 339	53 64	23 28	22.5	31.2	36.5	41.7	46.9	
15	17141	371 432	73 86	34 40	15.0	38.6	45.0	51.4	57.9	
20	23423	382 445	76 89	36 43	11.3	39.5	46.1	52.7	59.3	

<sup>a</sup>Numbers in tables depict short-run impacts.

<sup>b</sup>Estimated performance for \$3.50 and \$4.00 ex-vessel price.

<sup>c</sup>Maximum profit occurs for approximately 23-day trips.

<sup>d</sup>Quasi-fixed cost and 10% rate of return equals = \$330,000



extremely long trips, however, for tonnage class 3 vessels are less profitable.

An annual days at sea restriction of 150 days will likely achieve stated biological objectives but will pose considerable financial problems for the scallop fleet. Vessels operations will yield revenues that are insufficient, on average, to cover the fixed costs for either tonnage class 3 or tonnage class 4 vessels.

At an annual allocation of 200 days, tonnage class 3 vessels will tend to take 15 day trips to maximize net earnings. The larger vessels (tonnage class 4) will take 20-23 day trips. Consideration of product quality and crew satisfaction associated with longer trips may result in shorter trips. A 200 day per year allocation should allow most of the vessels in the fleet to remain in the fleet; sufficient revenues and returns to owner, captain, and crew should prevail. A fleet larger than 175 full-time vessels, however, will likely harvest well in excess of any desired target level under the 200 days at sea per year allocation (Table 6). For example, a full time fleet of 225 vessels operating at 200 days per year produces approximately 43.4 million pounds per year; a full-time fleet of 225 vessels operating at 150 days per year produces 32.6 million pounds a year which is probably higher than most desired target levels of harvest.

TABLE 6. ESTIMATED FLEET LANDINGS ANNUAL DAYS AT SEA  
 ALLOCATIONS OF 150, 200, AND 225 DAYS AND 1990 SIZE  
 DISTRIBUTION OF TONNAGE CLASS 3 AND TONNAGE CLASS 4 VESSELS

Annual allocations	Fleet Landings Number of Vessels							
	150		175		200		225	
	TC3 66	TC4 84	TC3 77	TC4 98	TC3 88	TC4 112	TC3 98	TC4 127
-----millions of pounds-----								
150 days	21.7		25.3		28.9		32.6	
200 days	28.9		33.7		38.5		43.4	
225 days	32.6		38.0		43.5		49.0	

#### Individual impacts:

Analyses presented, thus far, have been in terms of average performance and average impacts. It is important to realize that the various proposed regulations will elicit different responses and impacts among vessels. We illustrate the possibility for differential impacts by examining how various regulations might have affected 11 vessels operating in 1990.

We initially examined the layover system of 1:1 and 1:2 with the meat count in place. We then examined relaxing the meat count regulation and imposing a 10,000 trip limit, 1:1 and 1:2 layover day restrictions, and the 9 man crew. The influence of the 9 man crew is evaluated in terms of shucking capacity per man (Figure 1). We next examined using trip limits, layover days, 9 man crew, and 3.5-inch rings. Our final analysis examined 150 and 225 days at sea per year allocations.

#### 1990 meat count and layover:

If layover days of 1:1 had been in place in 1990 with the meat count standard, all 11 vessels would have been affected (Table 7). The impacts, however, would have substantially varied among vessels. Vessels realizing the restrictive nature of the layover, however, would have attempted to seasonally reorganize their fishing operations. Vessel owners and crew would realize that layover days

FACTOR REQUIREMENT ISOQUANT  
30 MINUTE SHUCKING PER 60 MINUTE PERIOD

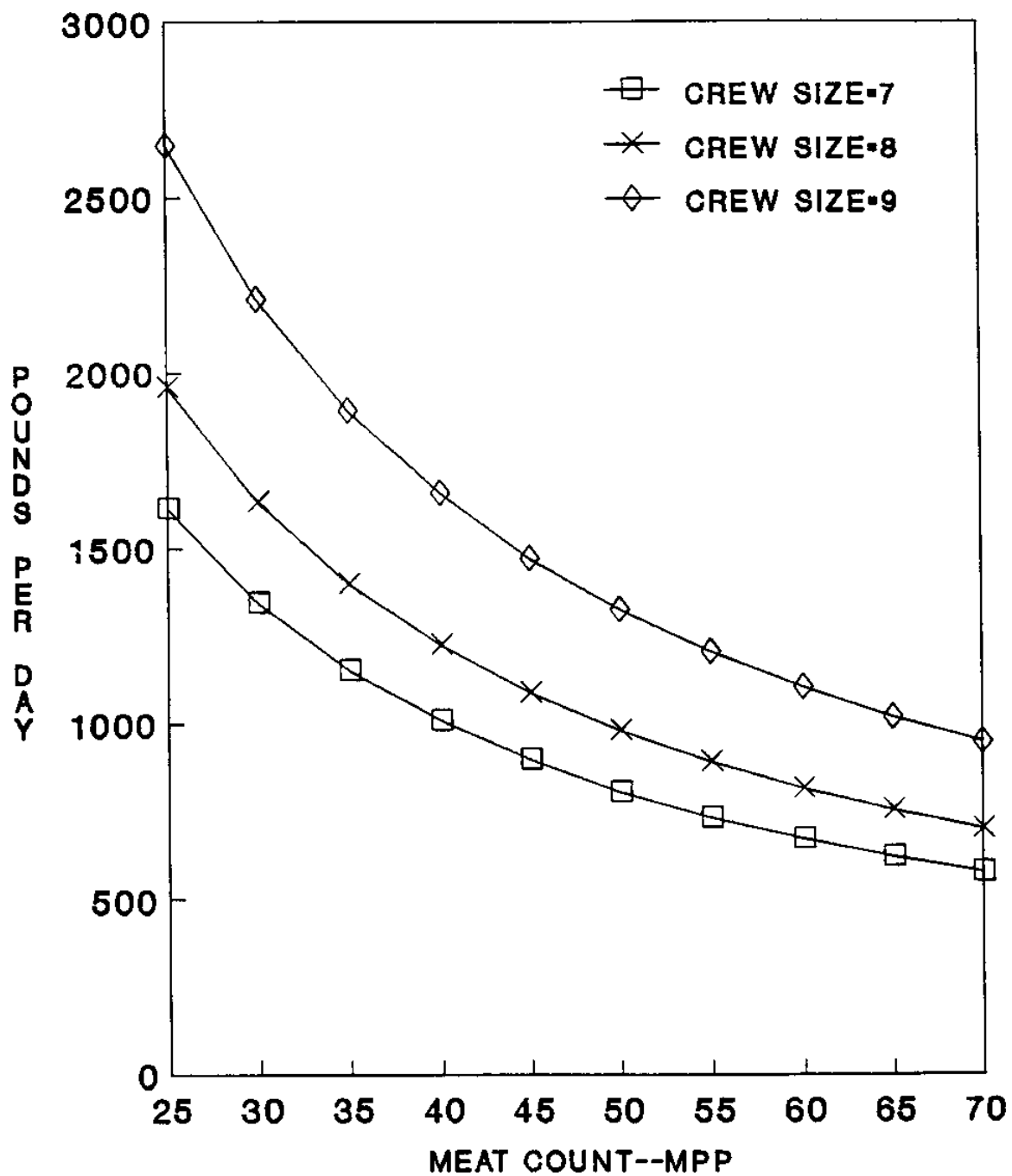


TABLE 7. ESTIMATED IMPACTS OF LAYOVER DAYS ON 11 VESSELS IN 1990 WITH THE MEAT COUNT STANDARD IN PLACE

Layover days	Trips	Days	Crew <sup>a</sup>	Actual catch	Fitted catch <sup>b</sup>	Actual revenue	Fitted revenue <sup>b</sup>
				--1,000 lbs--		-----\$1,000-----	
Actual <sup>c</sup>	20	258	8.85	181	180	673	674
1:1	13	182			145		524
SR <sup>d</sup>	12	182			145		529
1:2	19	248			176		657
SR	17	240			173		647
Actual	16	246	9.44	150	151	554	553
1:1	12	190			124		443
SR	11	191			128		471
1:2	16	246			151		553
SR	16	246			151		553
Actual	16	245	8.50	144	142	535	526
1:1	12	189			118		421
SR	11	186			114		422
1:2	16	245			142		526
SR	16	245			142		526
Actual	17	249	8.24	131	129	490	483
1:1	13	191			105		377
SR	12	180			98		367
1:2	16	238			123		458
SR	16	242			127		475
Actual	14	220	8.43	133	133	497	492
1:1	12	186			116		420
SR	11	180			113		414
1:2	14	220			133		492
SR	14	220			133		492
Actual	17	238	8.59	149	145	565	554
1:1	13	188			118		437
SR	12	186			116		436
1:2	17	238			145		554
SR	17	238			145		554
Actual	20	286	9.75	303	299	1142	1141
1:1	13	184			212		779
SR	11	183			217		793
1:2	17	241			262		977
SR	16	250			275		1032
Actual	15	190	9.33	117	115	428	422
1:1	14	182			113		413
SR	14	183			112		415
1:2	15	190			115		422
SR	15	190			115		422

TABLE 7. ESTIMATED IMPACTS OF LAYOVER DAYS ON 11 VESSELS IN 1990 WITH THE MEAT COUNT STANDARD IN PLACE  
CONTINUED

Layover days	Trips	Days	Crew	Actual catch	Fitted catch	Actual revenue	Fitted revenue
Actual	17	245	8.65	171	173	642	649
1:1	12	181			138		495
SR	12	185			136		516
1:2	17	245			173		649
SR	17	245			173		649
Actual	15	201	9.60	129	124	460	446
1:1	14	183			117		414
SR	13	180			116		412
1:2	15	201			124		446
SR	15	201			124		446
Actual	16	240	8.00	128	128	492	494
1:1	13	181			102		376
SR	11	189			107		392
1:2	16	240			128		494
SR	16	240			128		494

<sup>a</sup>Crew is average crew size for year.

<sup>b</sup>Fitted catch and revenue are the annual catch and revenue estimated by the models; fitted values should be compared to evaluate the potential impacts of a regulation. Actual catch and revenue are included only for the purposed of evaluating the models.

<sup>c</sup>Actual is what the vessel actually did in 1990 and reflects the meat count standard in place in 1990.

<sup>d</sup>SR indicates seasonal (S) reorganization (R); numbers in the SR row are estimates of economic performance after a vessel reorganized fishing activities to take advantage of known seasonal differences in resource abundance, meat yield, and ex-vessel price.

actually restrict the total number of days at sea per year. They would attempt to capitalize on periods when resource conditions and prices are most favorable and discount periods in economic returns are likely to be low. Analyses determined that vessels which could seasonally reorganize would have had higher harvest levels and revenues than without the seasonal reorganization but would have still been affected by the 1:1 layover. Moreover, these vessels would tend to take more long trips than they actually did in 1990. The 1:2 layover, in general, would have affected only those vessels having more than 250 days at sea per year in 1990 or vessels having many short trips and approximately 250 days.

10,000 pound quota, layover days, and 9 man crew:

Relaxing the meat count standard and imposing a 10,000 pound quota, layover day restrictions, and 9 man crew would have had a considerable impact on the 11 vessels in 1990 (Table 8). Interestingly, the 9 man crew would not have had any affect on trip and annual landings for 10 of the 11 vessels. This was determined by reviewing the information contained in Figure 1 which is based on numerous at-sea experiments. Harvest levels under the various regulations could have been achieved with crew sizes of 9 with minimal increased effort by the 9 man crew except for one vessel. Vessels could have also reorganized fishing operations on a seasonal basis to partially mitigate the detrimental effects of the regulations.

TABLE 8. ESTIMATED IMPACTS OF LAYOVER DAYS, 10000 POUND QUOTA, AND 9 MAN CREW ON 11 VESSELS IN 1990 WITHOUT A MEAT COUNT STANDARD IN PLACE

Layover days	Trips	Days	Crew <sup>a</sup>	Actual catch	Fitted catch <sup>b</sup>	Actual revenue	Fitted revenue <sup>b</sup>
				--1,000 lbs--		-----\$1,000-----	
Actual <sup>c</sup>	20	258	8.85	181	180	673	674
1:1	18	182			136		505
SR <sup>d</sup>	17	191			142		537
1:2	22	241			165		632
SR	22	241			165		632
Actual	16	246	9.44	150	151	554	553
1:1	15	181			119		432
SR	14	184			126		458
1:2	18	239			147		551
SR	18	239			147		551
Actual	16	245	8.50	144	142	535	526
1:1	15	188			122		447
SR	13	184			118		444
1:2	18	248			147		558
SR	18	248			147		558
Actual	17	249	8.24	131	129	490	483
1:1	14	181			113		409
SR	13	181			112		430
1:2	18	249			141		533
SR	18	249			141		533
Actual	14	220	8.43	133	133	497	492
1:1	14	186			125		470
SR	14	180			125		470
1:2	18	220			153		588
SR	18	220			153		588
Actual	17	238	8.59	149	145	565	554
1:1	16	188			126		472
SR	15	186			132		502
1:2	19	238			156		607
SR	19	238			156		607
Actual <sup>e</sup>	20	286	9.75	303	299	1142	1141
1:1	21	188			176		672
SR	21	188			176		672
1:2	24	231			216		851
SR	24	231			216		851
Actual	15	190	9.33	117	115	428	422
1:1	17	185			118		443
SR	17	185			118		443
1:2	20	237			143		556
SR	20	237			143		556



TABLE 8. ESTIMATED IMPACTS OF LAYOVER DAYS, 10000 POUND QUOTA, AND 9 MAN CREW ON 11 VESSELS IN 1990 WITHOUT A MEAT COUNT STANDARD IN PLACE--CONTINUED

Layover days	Trips	Days	Crew	Actual catch	Fitted catch	Actual revenue	Fitted revenue
Actual	17	245	8.65	171	173	642	649
1:1	17	191			142		536
SR	16	186			141		532
1:2	20	241			172		671
SR	20	241			172		671
Actual	15	201	9.60	129	124	460	446
1:1	16	184			119		434
SR	16	184			119		432
1:2	19	238			139		519
SR	19	238			139		519
Actual	16	240	8.00	128	128	492	494
1:1	15	189			111		425
SR	12	183			112		436
1:2	18	250			142		563
SR	18	250			142		563

<sup>a</sup>Crew is average crew size for year.

<sup>b</sup>Fitted catch and revenue are the annual catch and revenue estimated by the models; fitted values should be compared to evaluate the potential impacts of a regulation. Actual catch and revenue are included only for the purposed of evaluating the models.

<sup>c</sup>Actual is what the vessel actually did in 1990 and reflects the meat count standard in place in 1990.

<sup>d</sup>SR indicates seasonal (S) reorganization (R); numbers in the SR row are estimates of economic performance after a vessel reorganized fishing activities to take advantage of known seasonal differences in resource abundance, meat yield, and ex-vessel price.

<sup>e</sup>Only vessel for which 9 man crew would have restricted performance; estimated landings and revenues are adjusted to reflect 9 man crew shucking capability.

The 1:2 layover under the 10,000 pound limit and no meat count would have actually permitted 7 of the 11 vessels to realize higher annual landings and revenues that actually observed in 1990 under the meat count regulations. This would have occurred if they had taken the exact same number of days per trip as actually taken in 1990 and seasonally reorganized fishing activities.

Layover days, quota, 9 man crew, and 3.5-inch rings:

The marginal effect of adding the 3.5-inch ring to the other regulations was estimated to be quite significant in the short-run (Table 9). This was regardless of using a 1:1 or 1:2 layover. Harvest levels and revenues of all 11 vessels would have been substantially reduced below their observed 1990 levels. It is highly unlikely that any vessel complying with the regulations would have been able to cover fixed costs in 1990. It should be remembered, however, that reduced harvests and revenues caused by adding the 3.5-inch ring would likely be short-lived. Future growth (approximately 6-12 months) and recruitment would likely compensate for the large declines in the future.

150 and 225 annual days:

The impacts of days at sea restrictions vary depending upon actual days at sea per vessel in 1990 (Table 10). The 150 day restriction would have imposed extreme reductions in landings and revenues for all 11 vessels; they

TABLE 9. ESTIMATED IMPACTS OF LAYOVER DAYS, QUOTA, 9 MAN CREW, AND 3.5-INCH RINGS ON 11 VESSELS OPERATING IN 1990 AND NO MEAT COUNT REGULATION IN PLACE

Layover days	Trips	Days	Crew <sup>a</sup>	Actual catch	Fitted catch <sup>b</sup>	Actual revenue	Fitted revenue <sup>b</sup>
				--1,000 lbs--		-----\$1,000-----	
Actual <sup>c</sup>	20	258	8.85	181	180	673	674
1:1	16	187			114		415
SR <sup>d</sup>	15	191			116		428
1:2	21	248			135		510
SR	21	248			135		510
Actual	16	246	9.44	150	151	554	553
1:1	12	180			102		352
SR	12	187			101		371
1:2	17	252			123		452
SR	17	252			123		452
Actual	16	245	8.50	144	142	535	526
1:1	13	180			94		336
SR	12	189			96		355
1:2	17	248			116		432
SR	17	248			116		432
Actual	17	249	8.24	131	129	490	483
1:1	13	190			90		325
SR	13	186			88		330
1:2	17	248			109		409
SR	17	248			109		409
Actual	14	220	8.43	133	133	497	492
1:1	12	190			100		369
SR	12	192			100		371
1:2	16	250			122		461
SR	16	250			122		461
Actual	17	238	8.59	149	145	565	554
1:1	14	191			103		381
SR	13	193			107		404
1:2	18	247			126		481
SR	18	247			126		481
Actual	20	286	9.75	303	299	1142	1141
1:1	18	179			145		544
SR	17	194			158		600
1:2	22	247			186		722
SR	22	247			186		722
Actual	15	190	9.33	117	115	428	422
1:1	15	183			93		339
SR	15	183			93		339
1:2	19	243			114		436
SR	19	243			114		436

TABLE 9. ESTIMATED IMPACTS OF LAYOVER DAYS, QUOTA, 9 MAN CREW, AND 3.5-INCH RINGS ON 11 VESSELS OPERATING IN 1990 AND NO MEAT COUNT REGULATION IN PLACE--CONTINUED

Layover days	Trips	Days	Crew	Actual catch	Fitted catch	Actual revenue	Fitted revenue
Actual	17	245	8.65	171	173	642	649
1:1	14	188			114		417
SR	13	185			109		417
1:2	18	245			138		524
SR	18	245			138		524
Actual	15	201	9.60	129	124	460	446
1:1	15	192			101		360
SR	14	189			101		359
1:2	18	246			115		423
SR	18	246			115		423
Actual	16	240	8.00	128	128	492	494
1:1	14	193			90		341
SR	11	188			89		350
1:2	17	246			109		418
SR	17	246			109		418

<sup>a</sup>Crew is average crew size for year.

<sup>b</sup>Fitted catch and revenue are the annual catch and revenue estimated by the models; fitted values should be compared to evaluate the potential impacts of a regulation. Actual catch and revenue are included only for the purpose of evaluating the models.

<sup>c</sup>Actual is what the vessel actually did in 1990 and reflects the meat count standard in place in 1990.

<sup>d</sup>SR indicates seasonal (S) reorganization (R); numbers in the SR row are estimates of economic performance after a vessel reorganized fishing activities to take advantage of known seasonal differences in resource abundance, meat yield, and ex-vessel price.

TABLE 10. ESTIMATED IMPACTS OF 150 AND 225 ANNUAL DAYS  
ALLOCATION PER VESSEL ON 11 VESSELS OPERATING IN 1990 AND  
NO MEAT COUNT REGULATIONS IN PLACE

Annual days	Trips	Days	Crew <sup>a</sup>	Actual catch	Fitted catch <sup>b</sup>	Actual revenue	Fitted revenue <sup>b</sup>
				--1,000 lbs--	-----\$1,000-----		
Actual <sup>c</sup>	20	258	8.85	181	180	673	674
225	18	225			191		700
SR <sup>d</sup>							
150	11	150			145		525
SR	10	150			149		534
Actual	16	246	9.44	150	151	554	553
225	12	225			162		584
SR							
150	16	150			119		430
SR	9	150			124		451
Actual	16	245	8.50	144	142	535	526
225	12	225			158		579
SR							
150	16	150			117		416
SR	9	150			115		436
Actual	17	249	8.24	131	129	490	483
225	13	225			140		516
SR							
150	16	150			103		368
SR	10	150			103		383
Actual	14	220	8.43	133	133	497	492
225	12	220			153		571
SR							
150	14	150			111		406
SR	9	150			116		424
Actual	17	238	8.59	149	145	565	554
225	13	225			164		615
SR							
150	17	150			122		441
SR	10	150			124		457
Actual	20	286	9.75	303	299	1142	1141
225	13	224			297		1087
SR							
150	17	150			208		745
SR	9	150			230		828
Actual	15	190	9.33	117	115	428	422
225	14	190			135		492
SR							
150	15	150			109		390
SR	10	150			115		418

TABLE 10. ESTIMATED IMPACTS OF 150 AND 225 ANNUAL DAYS ALLOCATION PER VESSEL ON 11 VESSELS OPERATING IN 1990 AND NO MEAT COUNT REGULATIONS IN PLACE--CONTINUED

Annual days	Trips	Days	Crew	Actual catch	Fitted catch	Actual revenue	Fitted revenue
Actual	17	245	8.65	171	173	642	649
225	16	225			186		688
SR							
150	10	148			130		471
SR	9	150			135		506
Actual	15	201	9.60	129	124	460	446
225	15	201			148		529
SR							
150	11	148			118		412
SR	10	150			127		440
Actual	16	240	8.00	128	128	492	494
225	15	225			134		530
SR							
150	11	150			104		377
SR	9	150			108		415

<sup>a</sup>Crew is average crew size for year.

<sup>b</sup>Fitted catch and revenue are the annual catch and revenue estimated by the models; fitted values should be compared to evaluate the potential impacts of a regulation. Actual catch and revenue are included only for the purposed of evaluating the models.

<sup>c</sup>Actual is what the vessel actually did in 1990 and reflects the meat count standard in place in 1990.

<sup>d</sup>SR indicates seasonal (S) reorganization (R); numbers in the SR row are estimates of economic performance after a vessel reorganized fishing activities to take advantage of known seasonal differences in resource abundance, meat yield, and ex-vessel price.

Analysis of seasonal reorganization at 225 annual days has not been completed.

would not have been able to seasonally reorganize to deal with the large reductions. The magnitude of the impacts, however, would have considerably varied. A restriction of 225 days at sea would have allowed 10 of the 11 vessels to have higher landings and revenues in 1990 than they actually did because of the relaxation of the meat count standard.

#### Concluding Note

Analyses of the proposed regulations and associated levels that would have actually limited fishing activities of the 11 vessels in 1990 indicated that these vessels could likely reorganize fishing activities. For the most part, the vessels would tend to curtail or stop fishing activities between October and January.

Reduced domestic landings would allow Canadian, Mexican, South American, and particularly Chinese exporters an opportunity to better penetrate American markets and increase their market share. Interestingly, the months that American domestic production would decline are also the months usually having the highest ex-vessel prices. This would be an even greater incentive for foreign exporters to ship product to the United States. This particular aspect should be considered in designing an alternative regulatory strategy.

In conclusion, the 1:1 layover and 10,000 pound trip limit or a 150 days at sea allocation would inflict considerable financial harm on the U.S. sea scallop fleet. It

is doubtful than many vessels could endure these large reductions. Vessel owners having large capital reserves could probably endure these losses for a short-period until a sufficient number of vessels exited from the fishery; at that time, the regulations could be relaxed and the remaining firms would likely receive adequate economic returns.